MASTER OF SCIENCE
IN
ELECTRICAL ENGINEERING

DIRECT-SEQUENCE SPREAD-SPECTRUM ACOUSTIC COMMUNICATIONS WITH CRV DECOMPOSITION

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Direct-Sequence Spread-Spectrum (DS-SS) is among the preferred modulation techniques for military applications. DS-SS offers three greatly desired characteristics: it allows for the development of Low Probability of Detection (LPD) and Low Probability of Intercept (LPI) systems and has a very good performance in fading channels. This thesis investigates the performance of the "Cross-Product RV (CRV) decomposition" as the basis of blind-equalization algorithms. The CRV is a rank-revealing decomposition alternative to the Eigenvalue Decomposition (EVD) that can provide a recursively updated estimate of the signal and noise subspace at a reduced computational cost. The CRV updating algorithm is implemented in MATLAB and evaluated in a previously proposed communication scheme intended for use in an underwater acoustic network called Seaweb. The underwater channel is modeled with the Monterey-Miami Parabolic Equation Model (MMPE) for various multipath perturbations. The receiver performance is examined using a Monte Carlo simulation. Bit-error rates versus signal-to-noise ratio are presented for various noise assumptions as well as receiver synchronization assumptions.

KEYWORDS: Underwater Acoustic Communications, Seaweb, Reverberation, TL, Ambient Noise, Interface Roughness, Internal Waves, Turbulence, Volume Perturbations, Sound Speed Perturbations, Doppler, MMPE, Direct Sequence Spread-spectrum, Gold-codes, CRV Decomposition, Subspace Decomposition, Blind Equalization, Matched Filter

KILL VEHICLE EFFECTIVENESS FOR BOOST PHASE INTERCEPTION OF BALLISTIC MISSILES

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Boost phase interception of ballistic missiles is envisioned as the primary response of the layered defense architecture implemented in the ballistic missile defense system. A limited time frame in which to take action and the necessity to implement hit-to-kill technology in the kill vehicle counterbalances the many advantages of boost phase interception. Direct-hit missile technology is constrained by the requirement to minimize miss distance to a negligible amount between the kill vehicle and optimum aimpoint on the target. This thesis examines kill vehicle effectiveness, which is tantamount to miss distance, as a function of both the kill vehicle maximum acceleration capability and the guidance system time constant necessary to destroy a target. The kill vehicle guidance system is modeled in MATLAB as a fifth order binomial series with proportional navigation. The simulation examines the effect of an accelerating target attributed to powered flight and aimpoint displacement caused by a shift in tracking point from the target plume to the payload when resolution occurs. The kill vehicle minimum requirements, as indicated by the simulation, include a lateral acceleration capability of four times the target acceleration and a guidance system time constant that is less than one-tenth the estimated flight time.

KEYWORDS: Ballistic Missile Defense System, Layered Defense, Boost Phase Interception, Kill Vehicle, Hit-to-kill, Proportional Navigation

HARDWARE-IN-THE-LOOP CONTROL OF A CASCADED MULTI-LEVEL CONVERTER

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Next-generation U.S. Navy destroyers, known as DD(X), will use electric drive motors to meet their propulsion needs instead of the traditional mechanical drives. The use of electric drive motors in naval vessels has spurred the development of high power converters. This thesis examines the feasibility of using an advanced control algorithm known as Sine-triangle Pulse Width Modulation (SPWM) in combination with a Cascaded Multi-Level Converter (CMLC) in order to meet the U.S. Navy's strict requirements. The SPWM control algorithm is designed in Simulink and experimentally tested on a CMLC previously constructed at the Naval Postgraduate School. The controller and converter successfully power a quarter horsepower three-phase induction motor.

KEYWORDS: DC-AC, Multi-level, Cascaded Multi-level, Converter, Inverter, Sine-triangle, Space Vector Modulation, dSPACE, IPS, DD(X)

ADVANCED THERMOPHOTOVOLTAIC CELLS MODELING, OPTIMIZED FOR USE IN RADIOISOTOPE THERMOELECTRIC GENERATORS (RTGS) FOR MARS AND DEEP SPACE MISSIONS

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Thermophotovoltaic (TPV) cells are a good candidate for use in high efficiency radioisotope thermoelectric generator (RTG) power devices for deep space missions. This thesis examines the use of Silvaco Virtual Wafer Fabrication Software as a tool for designing and optimizing TPV cells for different possible spectrums. Results are presented for gallium antimonide (GaSb) and indium gallium arsenide (InGaAs) cells optimized to the AM0 spectrum. These results closely match published data as well as hypothetical cells optimized to the spectrum of a 1300 K blackbody.

KEYWORDS: Thermophotovoltaic Cell, Radioisotope Thermoelectric Generator, Optimization, Model, Silvaco, GaSb, InGaAs

IMPROVED METHOD FOR SIMULATING TOTAL RADIATION DOSE EFFECTS ON SINGLE AND COMPOSITE OPERATIONAL AMPLIFIERS USING PSPICE

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This research is part of a continued effort to simulate the effects of total dose radiation on the performance of single and composite operational amplifiers using PSPICE, circuit simulation software. This research provides further verification that the composite operational amplifier has a superior performance to the single operational amplifier while operating in a radiation flux. In this experiment, a single and composite op amp are constructed in PSPICE and implemented in a finite gain amplifier circuit. The effects of

ionizing radiation are simulated by varying the parameters of the components that made up the op amps. These component parameters are varied in ways that mimic the response of the actual components that were irradiated in previous research. The simulations are incrementally run to simulate an increasing radiation dose. The results of these simulations are then compared with the results of an actual study conducted at the Naval Postgraduate School, where similar circuits were irradiated using the school's linear accelerator, LINAC. This procedure proves to be an improved method for predicting the effects of total dose radiation for radiation hardened devices, and provides additional confirmation of the superior performance of the composite op amp over the single op amp.

KEYWORDS: Total Dose Radiation, Single Operational Amplifier, Composite Operational Amplifier, Simulated Radiation Dose

CHARGE TRANSPORT STUDY OF INGAAS QWIPS

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A series of experiments are performed to characterize the material properties of InGaAs/GaAs for use in a two-color quantum-well IR photodetector (QWIP) design. Results from room temperature studies using cathodoluminescence and photoluminescence indicate light emission at 858 nm and 1019 nm from GaAs and InGaAs, respectively. Using a direct transport imaging technique, an edge dislocation pattern is observed as confined to the InGaAs layer of the material. A dislocation density measurement is performed and is less than 2000 lines/cm. Quantitative intensity level measurements indicate fluctuation in the region of dislocations to be less than 30% of the signal to background level. Finally, a spot mode study using the direct transport imaging method is performed to evaluate the feasibility of using this technique for contact-less diffusion length measurements.

KEYWORDS: IR Detectors, Two-color QWIPs, Cathodoluminescence, InGaAs/GaAs, Direct Transport Imaging, Contact-less Diffusion Measurements

INFRARED FACE RECOGNITION

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This study continues a previous face recognition investigation using uncooled infrared technology. The database developed in an earlier study is further expanded to include 50 volunteers with 30 facial images from each subject. The automatic image reduction method reduces the pixel size of each image from 160×120 to 60×45. The study reexamines two linear classification methods: the Principal Component Analysis (PCA) and Fisher Linear Discriminant Analysis (LDA). Both PCA and LDA apply eigenvectors and eigenvalues concepts. In addition, the Singular Value Decomposition based Snapshot method is applied to decrease the computational load. The K-fold Cross Validation is applied to estimate classification performances. Results indicate that the best PCA-based method (using all eigenvectors) produces an average classification performance equal to 79.22%. Incorporated with PCA for dimension reduction, the LDA-based method achieves 94.58% accuracy in average classification performance. Additional testing on unfocused images produces no significant impact on the overall classification performance. Overall results again confirm uncooled IR imaging can be used to identify individual subjects in a constrained indoor environment.

KEYWORDS: Uncooled Infrared Imaging, Face Recognition, Principle Component Analysis, Fisher Linear Discriminant Analysis, SVD Decomposition, Cross Validation

REAL-TIME DATA ACQUISITION AND PROCESSING OF THE MAGNETIC, ANGULAR RATE AND GRAVITY (MARG) SENSOR

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This research involves the development of a human-body motion tracking system constructed with the use of commercial off-the-shelf (COTS) components. The problem to be solved is that the data from the motion tracking sensors must be transmitted wirelessly in real time from a microcontroller to a server computer. Due to the fact that the microcontroller does not support a standard operating system (OS), widely used Personal Computer Memory Card International Association (PCMCIA) cards or Universal Serial Bus (USB) wireless modules cannot be used. The wireless communication module chosen for this purpose is the DPAC Technologies' Airborne wireless module, a highly integrated 802.11b module that can be easily integrated with the microcontroller.

The evaluation of the module is completed in four stages. The first part is to initiate communication with the DPAC module. The second part is to establish communication between the DPAC module and a TCP server. The third part is to establish communication between the microcontroller and the DPAC module. The fourth part is to increase the baud-rate to the desired high value of 230,400 bps.

The evaluation result indicates that the DPAC Airborne wireless 802.11b module meets the wireless communication requirements of the motion tracking system.

KEYWORDS: MARG III Sensor, Control Interface Unit, CIU, Microcontroller, RS232, UART, PCMCIA, USB, Wireless Communication, 802.11, 802.11b, WiSER 2400, DPAC Airborne

ADVANCED TECHNIQUES TO IMPROVE THE PERFORMANCE OF OFDM WIRELESS LAN

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Orthogonal frequency-division multiplexing (OFDM) systems have experienced increased attention in recent years and have found applications in a number of diverse areas, including telephone-line based Asymmetric Digital Subscriber Line (ADSL) links, digital audio and video broadcasting systems, and wireless local area networks (WLAN). OFDM is a powerful technique for high data-rate transmission over fading channels. However, to deploy OFDM in a WLAN environment, precise frequency synchronization must be maintained and complicated frequency offsets must be handled. In this thesis, various techniques to improve the data throughput of OFDM WLAN are investigated. A simulation tool is developed in MATLAB to evaluate the performance of the IEEE 802.11a physical layer. A rapid time and frequency synchronization algorithm using only the short training sequence of the IEEE 802.11a standard is proposed, thus reducing the training overhead by 50%. Particular attention is paid to channel coding, block interleaving, and antenna diversity. Computer simulation shows that drastic improvement in error rate performance is achievable when these techniques are deployed.

KEYWORDS: OFDM, WLAN, IEEE 802.11a, Exponential Channel Model, Packet Detection, Frame Synchronization, Frequency Synchronization, Carrier Offset, Phase Noise, Pilot Phase Tracking, Channel Estimation, Equalization, Scrambling, Convolutional Coding, Interleaving, Maximal Ratio Combining, Selection Diversity, Viterbi Algorithm, Soft Decision Decoding, Puncturing

AN INVESTIGATION OF A MULTIPLE-INPUT-MULTIPLE-OUTPUT COMMUNICATION SYSTEM WITH THE ALAMOUTI SPACE-TIME CODE

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This thesis investigates the fundamentals of multiple–input–multiple–output (MIMO) radio communication systems with space–time codes. A MIMO system is designed using the Alamouti space–time code. The modulation technique is binary phase-shift keying (BPSK). MATLAB with Simulink is used to simulate the design, which is tested in both an additive white Gaussian noise (AWGN) channel and in a multipath fading channel with AWGN. Theoretical performance is derived for both channels and compared to simulated results. The original receiver design is changed to incorporate a maximal-ratio combiner (MRC) receiving technique with channel state information (CSI). The theoretical performance for this design is determined and compared to simulated and published results.

KEYWORDS: Multiple Input Multiple Output, Alamouti Scheme, Space-time Coding, Binary Phase-shift Keying, Rayleigh Fading Channel, Multipath Fading Channel, Maximal Ratio Combining, Spectral Efficiency, Channel Capacity, MIMO, BPSK, MRC

A THREE-PHASE HYBRID INVERTER SYSTEM UTILIZING HYSTERESIS CONTROL

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Naval vessels of the future will require lighter, more compact, and more versatile power electronics systems. With the advent of the DC Zonal Electrical Distribution System, more innovative approaches to the conversion of the DC bus power to AC power for motor drives will enhance the efficiency and warfighting capability of tomorrow's ships. This thesis explores the concept of a hybrid DC-AC power converter that combines a hysteresis controlled inverter with a six-step bulk inverter. A six-step bulk inverter is built from discrete components and tested in simulation and hardware. The two inverters are connected in parallel to provide a high-fidelity current source for a three-phase load. The addition of the hysteresis inverter to the bulk inverter adds a closed current loop for more robust control and improves the quality of the output load current.

KEYWORDS: Hybrid Inverter, Hysteresis Control, Inverter, Parallel Inverters, Six-step Inverter, Shipboard Motor Drives